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ABSTRACT

This paper argues that the fields of education and neuroscience have much to offer one another, suggesting that educators can benefit from neuroscience research by better understanding normal and abnormal behavior and thus creating innovative paradigms of learning and instruction. The paper also suggests that brain researchers might be able to draw from education to better understand brain functioning. For educators, brain research may be used to facilitate the development of improved models of learning and cognition, models which could benefit educational practice. Neuroscience may indirectly benefit students with learning, cognitive, or emotional disabilities by facilitating attitudinal changes on the part of educators who may limit students with their preconceived notions. Given the growing understanding of how the brain functions, it makes sense to include it in the educational equation. Educators' conceptions of learning may encourage neuroscientists to take a wider perspective on neural mechanisms underlying the learning process. Educators have the benefit of observing cognitive functioning in one of the best laboratories available (the school), which is a very different approach from that of neuroscientists who tend to study brain structure and function in isolation. Given that learning is a process affected by contextual factors in the environment, interaction between neuroscientists and educators may facilitate greater understanding of how the brain functions in various learning situations. (Contains 16 references.) (SM)

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Reciprocal Interaction and the Brain-Education Dilemma

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Abstract

This paper argues that the fields of education and neuroscience have much to offer one another. Specifically, it is argued that educators benefit from neuroscientific research to better understand normal and abnormal behavior and the creation of innovative paradigms of learning and instruction. In addition, it is proposed that brain researchers might be able to draw from education toward a better understanding of brain functioning.

Introduction

Recently, educators have been criticized for their attempts to utilize brain research as a means of informing educational policy and practice. Most notably, Bruer (1997, 1998) has argued that educators have oversimplified and misinterpreted neuroscientific research in their zeal to apply it to current educational problems. In his 1997 article, The Brain and Education: A Bridge Too Far, he identified several articles in both educational journals (e.g. The American School Board Journal) and the popular media (e.g. Newsweek, Chicago Tribune) that inappropriately cited neuroscientific research as a means to support their respective positions. Specifically, he indicated that these articles overestimated the relevance that neurodevelopmental research (e.g. synaptogenesis and pruning) has for the field of education. In his paper, Bruer concluded that educators should not attempt to attempt to apply neuroscience to policy and practice decisions. In fact, he stated that not even neuroscientists are clear as to the potential applicability of brain research to education. Bruer's (1997) recommendation, therefore, is for educators to utilize the existing bridge between education and cognitive science as a means of developing more sound educational policies and practices rather than attempting to bridge an impossible gap with neuroscience.

While Bruer makes a poignant argument about the problems inherent in the indiscriminate application of brain research, he excludes the potential benefits that might come from an educational community that becomes more knowledgeable about neuroscience. If we look beyond specific applications and view brain research as a mechanism for improving current conceptions of cognition and enhancing our understanding of individual differences, then we find that brain research has much to offer education. In addition, through enhancing our understanding of the neurological mechanisms underlying learning, educators may be able to benefit the field of neuroscience, thereby improving researchers' understanding of the structural and functional organization of the brain. In a workshop cosponsored by the Education Commission of the United States and the Charles A. Dana Foundation (1996), a number of educators, neuroscientists, and psychologists came together in order to address the possibility of developing an open dialogue between the fields of neuroscience and education. In a summary of that workshop, it was concluded that "collaborations between the two fields might yield practical information and suggest future avenues for investigation" (Education Commission of the United States, 1996, p. 4). The purpose of this paper, therefore, is two-fold: a) to discuss the potential benefits of reciprocal interaction between the fields of neuroscience and education and b) to address the necessity for developing an open dialogue between the two fields in order to reduce misunderstanding and improve our knowledge of the brain and its role in our everyday lives.

Reciprocal Interaction: Benefits for Educators

As mentioned above, our present understanding of the structure and function of the brain precludes educators and neuroscientists alike from deriving specific educational applications from brain research. This, however, does not mean that brain research cannot benefit educators at this time. On the contrary, educators may benefit from research in a variety of indirect ways. For the purpose of this argument, however, only two implications are discussed in this section.

The first implication of brain research that it may be used to facilitate the development of improved models of learning and cognition - models which may be beneficial to educational practice. For example, neuroscience has provided evidence that the brain is a dynamic organ that processes information on multiple and interacting, levels (Languis and Miller, 1992). Unfortunately, schools often fail to its comprehensive functioning into account as many students are still required to learn in the same rote, unidimensional manner they always have. Therefore, by becoming involved with neuroscience, educators may begin to design instructional models that are more brain-friendly, thereby engaging the whole student in learning.

The second implication of neuroscience is that it may indirectly benefit students with learning/cognitive/emotional disabilities by facilitating attitudinal changes on the part of educators. Frequently, students' performance problems are attributed to motivational rather than brain factors, even when a previous disability diagnoses have been made. The result is that many students' learning difficulties are discounted, and indeed, punished in school. This discounting may be reversed, however, as teachers become more involved in understanding how cognitive performance is affected by anomalies in the brain. To be sure, even rudimentary understanding of neuropsychological and neurophyiological phenomena may increase the salience of learning disorders to teachers, thereby reducing negative attitudes.

Re-conceptualizing Cognition and Instruction

Bruer (1997) argued rather strongly that instead of trying to build bridges with neuroscience, educators should utilize the already existing bridge with cognitive science. In Classroom Lessons: Integrating Cognitive Theory and Classroom Practice, he wrote that "cognitive science brings to education theories and methods that yield fine-grained analysis of the mental representations and processes that underlie learning and intelligent performance..." (P. 274). He further stated that classrooms often fail to encourage active and strategic learning and does not take into account students' "domain-specific learning trajectories" (p. 275). Upon first glance, Bruer's position appears to be a tenable one. After all, most teachers do want their students to be active and strategic learners and to build more comprehensive domains of knowledge. Unfortunately, the manner in which this is accomplished (through cognitive science) often leads students back down the same non-reflective path of rote memorization and use of mental technique that has hindered student progress since the inception of school. For example, in McGilly's Classroom Lessons, various learning programs based on cognitive science were described. In several of the programs, a heavy focus was placed on training students in cognitive strategy use, with the goal of increasing their ability to regulate their own learning. Other programs described efforts to improve students' storage of subject-specific information using social interaction and elaboration techniques. Interestingly, while developers reported accomplishing the goals for which they set out, one still cannot help noticing that they minimized more reflective and comprehensive forms of processing. In fact, there was little effort to engage students in more insightful modes of learning. Therefore, the brain was left out of the programs in McGilly's book.

Essentially, the problem with basing educational practice solely on principles of cognitive science (as advocated by Bruer) is a tendency to a) emphasize the acquisition of domain-specific knowledge without engaging students in more reflective consideration of the material, b) de-emphasize multiple contributing sources to learning (both internal and external), and c) place learners in the position of not only having to internalize domain-specific concepts, but also the steps necessary to be more "efficient" processors of information. Therefore, classroom learning becomes a mechanistic process, devoid of the fluidity found in natural learning environments. Consider the information processing model. According to this perspective, information is attended to, processed/elaborated upon, and stored under the direction of a central executive. The question then becomes, "What about more dynamic forms of learning?" "Does the central executive guide the entire processing system?" Interestingly, the answer to this question may be forthcoming as educators strive to discover the relationship between the brain and education.

In 1992, a number of papers were published in Educational Psychologist that provided brain-based conceptions of learning and cognition. In one conception, Iran-Nejad, Marsh, and Clements (1992) proposed a biofunctional model of cognition in which two forms of self-regulation guide the learning process. One form was that of active self-regulation, which corresponds to the central executive notion inherent in the information processing model. This self-regulatory system guides an individual's active attention toward internal and external information and the processing of that information. The second form of self-regulation proposed was that of dynamic self-regulation, which incorporates many of the brain's implicit processes. These processes are, in effect, the result of the ongoing functioning of the central nervous system. Based on Iran-Nejad (1990) and Iran-Nejad, March, and Clements (1991) biofunctional conception, therefore, educators should strive to engage students' entire functioning in the learning process. In effect, they are encouraged to stimulate both active and dynamic self-regulation in their students in order to facilitate constructive learning.

In an unpublished manuscript by this author (1998), posttraumatic stress disorder (PTSD) was re-conceptualized from a biofunctional perspective. One of the main reasons for doing this was to address the role of implicit processing in trauma learning - processes that appear to be purely biological in nature (or under dynamic self-regulatory control). Importantly, dynamic self-regulation was implicated in neurohormonal (i.e. cortisol and norepinephrine) dysregulation following traumatic exposure. This appears to reflect the body's capacity to re-regulate itself on its own in order to prepare itself for future threat. Although implicit processes were strongly implicated in this conception of learning, active self-regulation was also identified as a factor in the creation and maintenance of PTSD symptoms. Specifically, this form of self-regulation appears to play a key role in one's ruminative/negative thinking and active avoidance of stress-inducing stimuli (thereby reducing one's opportunities for learning more adaptive coping mechanisms). This model implies the need for several types of interventions. First, a clinician treating a client with PTSD will likely need to help the person to learn to regulate his/her physiological functioning (particularly in times when the person is being exposed to a stressful stimulus) through interventions such as relaxation training and systematic desensitization.

Second, a clinician may encourage the client to become more involved in previous activities or hobbies that he/she has actively avoided. By engaging in these activities, the idea is to reduce the active worrying and negative thinking that may pervade the individual's cognitive activity on a daily basis. Finally, some training in cognitive strategies may be appropriate. However, this should not be done to the exclusion of opportunities to help the client regulate his/her behavior in a more dynamic fashion. For example, working with the client on developing a more effective coping "attitude" through reflection and insight may be of greater benefit than simply trying to memorize coping statements per se. Once again, the goal is dynamic, system-wide involvement during learning.

In summation, given our growing understanding of the how the brain functions, it does not make sense to leave it out of the educational equation. To be sure, Iran-Nejad (1998) addressed this issue when he talked about the issue of relevance in education. His argument - as it is here - is that it is the brain that learns, thereby making it the central figure in human cognition. In addition, since the brain is what we are actually teaching to, then an understanding of how it works is necessary for informing instructional practice. Therefore, if we accept Bruer's position that educators should not become involved in neuroscience, we may be resigning ourselves to future generations of students who are less capable of reflecting thinking and more convergent in their approaches to problems.

Understanding Normal and Abnormal Behavior

Although educators and counselors alike are trained to reduce personal biases, this does not mean that they are immune to negative attitudes and behaviors (Crowson and Satcher, 1996). In fact, it may be that individuals with learning/cognitive/emotional problems are more likely to have their disabilities discounted due an inability by others to directly perceive them (i.e. visually). Certainly, this phenomenon has been observed by this author while working with a number of clientele in mental health practice. For example, a client recovering from a brain aneurysm once reported that family members inquired why he was unable to go back to work, even though he had significant problems with concentration, mood lability, and memory likely due to frontal lobe damage. Therefore, since this person's disability was not as salient to family members as if he exhibited a terrible scar or an inability to walk due to an orthopedic problem, their attitudes were much less supportive than they could have been.

It seems logical to assume that by increasing public and professional knowledge of brain functioning and difficulties, negative attitudes may be attenuated. This has already been the case to a certain extent for individuals suffering from mental illness (MI). In the past, MI was more likely to be attributed to constitutional or motivational factors. For example, the tendency for depressed persons to isolate themselves and withdraw from daily routines were often attributed to an unwillingness to be productive or the absence of industrious personality traits. Today, (although stigma has not been eliminated) more people are willing to accept depression as a legitimate illness. This appears to be, in large part, due to the flood of information entering the popular media from the brain sciences. To be sure, many mental illnesses are now popularized as "brain diseases".

Given that attitudes can be shaped by information, it makes sense for classroom teachers to take more interest in studying the brain's physiology and functions. Unfortunately, there is still a large tendency to attribute learning problems solely to motivational factors, particularly in individuals who have a history of behavioral problems. In fact, it is not uncommon for teachers to say to parents, "Johnny could do much better if he would put more effort into it". Unfortunately, this statement puts sole responsibility for learning in Johnny's hands and does not address the possibility that an underlying learning/cognitive/emotional disability exists. Further, if Johnny has already been diagnosed with a learning/cognitive/emotional deficit, his performance may still be attributed to purely motivational factors due to the lack of salience (i.e. visual presence) of the disability. Certainly, this narrow focus is not acceptable in other fields like medicine. In fact, any doctor that does not at least rule out other possibilities for a patient's problem before coming to a final decision about its underlying causation may find him/herself treating the wrong thing. Teachers too, need to be aware of the possibility. Therefore, just as doctors have medical training that might help them to more reflectively make decisions about diagnoses, brain research might improve the quality of educators' attitudes and behaviors towards students with learning problems.

Reciprocal Interaction: Benefits for Neuroscientists

To say that educators are the only ones who might benefit through collaboration with neuroscientists would surely underestimate the interaction. To be sure, neuroscience might benefit indirectly in a similar manner as educators. In considering how educators might benefit neuroscience, two possibilities are presented here. First, educators may benefit neuroscience by providing them with newer and more creative models of learning, thus providing possible direction in the study of brain functioning. In addition, they may help neuroscientists to better understand how the brain interacts with environmental factors during the learning process. Secondly, the types of questions that educators ask regarding potential applications may lead neuroscientists towards a greater consideration of learning implications of brain research (Education Commission of the States, 1996).

Re-conceptualizing Brain Functions

Just as an understanding of neuroscience may allow educators to re-conceptualize cognition into more dynamic models, so too may educators facilitate the re-conceptualization of brain functioning. First, educators' conceptions of learning may encourage neuroscientists to take a wider perspective on neural mechanisms underlying the learning process. For example, models such as those of Iran-Nejad and Marsh (1992) and Crowson (1998) provide perspectives on learning mechanisms that are quite different from traditional information processing theory - a theory that tends to focus solely on explicit memory systems and linear processing. In fact, while brain research often draws from information processing conceptions, the models presented above provide a radically different conception of brain activity - that of simultaneity and interdependency among subsystems. Therefore, as educators speculate about possible neural mechanisms underlying learning, they may pave the way to more comprehensive conceptions of learning by neuroscientists and facilitate research in those areas. Secondly, educators have the benefit of observing cognitive functioning in action in what is arguably the best laboratory to do so: the school. This is quite a different approach than that of neuroscientists who tend to study brain structure and function in isolation. Given that learning is a process affected by contextual features in the environment, interaction between neuroscientists and educators may facilitate greater understanding of how the brain functions in various learning situations.

Making Neuroscience More Applicable to Social and Educational Problems

Often times, scientific research is perceived as being undertaken without regard to real life problems. In fact, McCall (1988) speculated that this is one of the main reasons why journalists misinterpret scientific research. In his article he reported that "scientists strive to discover general laws or principles" while journalists seek "concrete example(s) and real-world application(s)" (p. 88) to report to the public. Interestingly, educators often find themselves in the same situation as journalists. To be sure, educators seeking to develop more constructive educational policies and practices often find themselves attempting to interpret neuroscientific research without the benefit of the scientists themselves. Obviously, this may result in inaccurate interpretations of research and improper speculations about how to apply research. Through reciprocal interaction, therefore, the questions that educators ask may serve to encourage neuroscientists to seek principles of application that reach far beyond the laboratory. In addition, interaction, may lead to greater collaboration in answering those questions.

Building a Collaborative Relationship

In The Reflex Arc Concept in Psychology, Dewey (1896) argued against individual experience being segmented into "rigid distinctions between sensations, thoughts, and acts" (p. 358). To be sure, he advocated for a more integrated view of human behavior. Unfortunately, the dichotomy between internal and external experience that he identified still pervades much of our study of learning today. In fact, this dualistic perspective may very well be what is holding back the creation of educational policies and practices that may enhance student learning and performance. Further, it may be hindering neuroscientists in their efforts to move beyond simple descriptions of neurological functioning towards a more comprehensive understanding of the brain. In each case, lack of interaction may contribute to overly simplified conceptions of human experience.

In an article by Murphy and Woods (1996), they proposed that the development of an integrated research agenda across knowledge domains would likely result in a more comprehensive understanding human behavior than is currently being realized. In addition, they argued that theoretical territoriality has maintained our limited understanding of how people learn. Therefore, by "tearing down...arbitrary markers, (this) will... encourage the birth of new, innovative ideas" (p. 144) - those that are likely to move both education and neuroscience beyond the simplistic conceptions of behavior held by both fields today.

Conclusion

In recent years, neuroscience has significantly advanced our understanding of the structural and functional organization of the brain. These advancements been buttressed by the development and refinement of technologies (Andrews, 1997) that allow for greater examination of physical systems and the measurement of neuropsychological phenomena. While progress in neuroscience has allowed researchers to better understand how they brain functions, educators have become more interested in the way that this research may be applied to educational policy and practice. This increased interest on the part of educators may be due in part by several factors: a) the need to provide more appropriate educational services to a student population that is growing ever more diverse, b) criticism of educators for teaching "to the test" rather than facilitating "learning skills that apply across the curriculum" (McGilly, 1994, p. 3), and c) a greater push towards accountability in education. It seems that educators have always striven for newer and more effective methods for informing their practice. Unfortunately, in the case of brain research direct applications are not readily discernable. This, however, does not mean that educators cannot benefit from neuroscientific research. Rather, this research may serve to indirectly benefit the field. In this paper two indirect applications were discussed: 1) the re-conceptualization of cognitive models of learning and 2) the fostering of greater appreciation for student diversity. In addition to the benefits educators may derive from reciprocal interaction, it appears likely that scientists could benefit as well. Specifically, neuroscientists may use this interaction in order to devise more comprehensive approaches to studying the brain. In addition, they may draw from questions about implications in constructing applications outside the laboratory.

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